Global HANPP and ecosystem services: possible research directions

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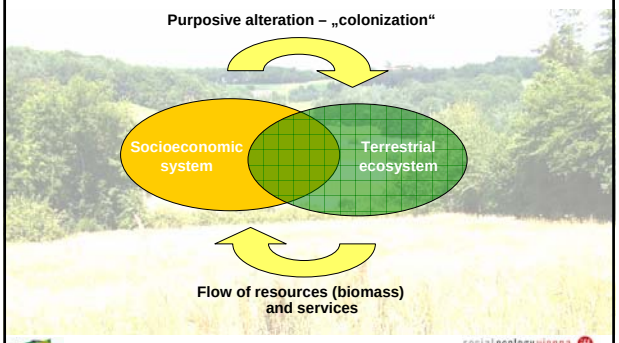
GLP SSC meeting
Capetown, South Africa, 5-9 May 2008

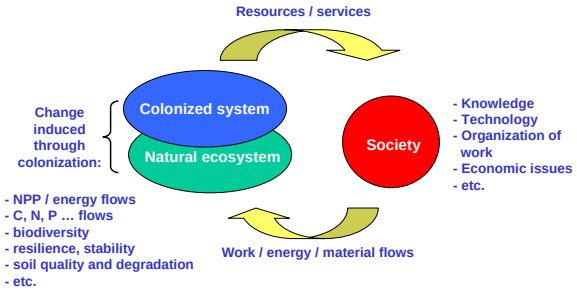
Overview

- Background: the integrated land system
- Global HANPP: pattern and magnitude
- Socioeconomic biomass metabolism and embodied HANPP
- Embodied HANPP and bio-energy: research questions
- Towards an „embodied HANPP“ perspective on global biomass trade
- Examples for research questions related to interregional decoupling of drivers and impacts

The integrated land system

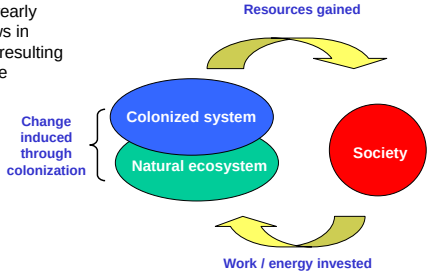


Land use: human colonization of terrestrial ecosystems

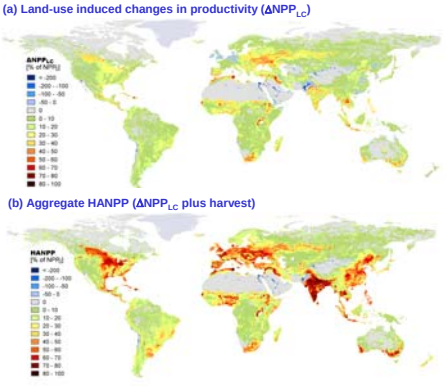


HANPP: measuring impacts of land use

HANPP measures changes in yearly biomass flows in ecosystems resulting from land use

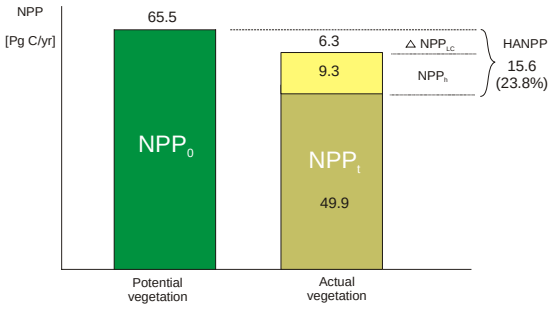


Global HANPP

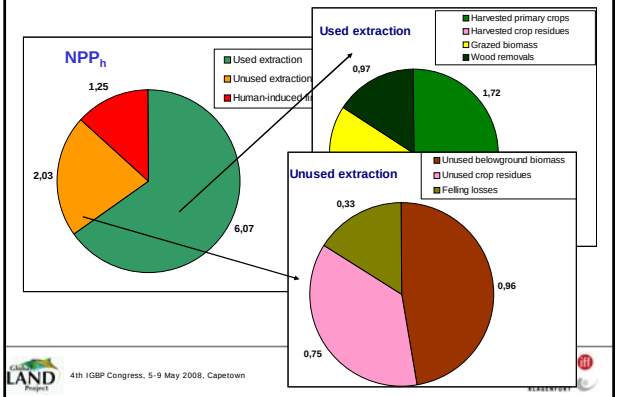


Haberl et al., *Proc. Natl. Acad. Sci. (USA)*, **104**, 12942-12947 (2007)

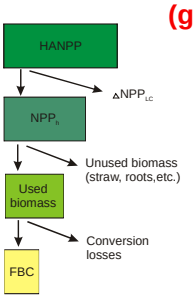
Aggregate global HANPP (year 2000)



Dissecting NPP_h



Embodied HANPP of final biomass use (global average)



1 ton of dry-matter biomass (final use of food, fibre, timber, fuel)

implies (in the global average over all products and regions)

the harvest of **3.6 tons** of primary biomass (NPP_h)
a reduction of productivity of **2.4 tons** ($\triangle NPP_{LC}$)

i.e. a total HANPP of **6 tons**

Krausmann et al., *Ecological Economics*, 65:471-487 (2008).

Some figures on current and projected future use of bio-energy

• Current global energy production from biomass	45 EJ/yr (±10)
• Potential in 2050 according to the World Energy Assessment [2000]	≤ 280 EJ/yr
• World Energy Council/IIASA scenario for 2050	≤ 154 EJ/yr
• SRES-IPCC scenarios for 2050	≤ 193 EJ/yr
• Long-term potential estimates (various authors)	≤ 1 135 EJ/yr

For comparison:

• Current terrestrial NPP (above+belowground)	2 200 EJ/yr
• Current global human fossil fuel use (GCV, 2005)	390 EJ/yr
• Total current human harvest of biomass (NPPh)	350 EJ/yr
• Total current used biomass harvest	224 EJ/yr

Embodied HANPP of biofuels (rough estimates, should be improved)

„Energetic recycling" of biomass wastes	No additional HANPP (but limited potential) **0 t HANPP per t of solid biofuel**
Integrated optimization of grain production for food & energy	Increases area-demand for grain production by c10% 50% of straw available for energetic use **0.2 t HANPP per t of solid biofuel**
Rape methyl ester (RME) as agro-fuel (diesel motors)	Assumtions: 0.13 kg RME per m^2 cropland and year HANPP per m^2 cropland and year 1.8 kg 50% of HANPP allocated to RME (remainder to feedstuff produced) **7 t HANPP per t of liquid biofuel (RME)**

Implications

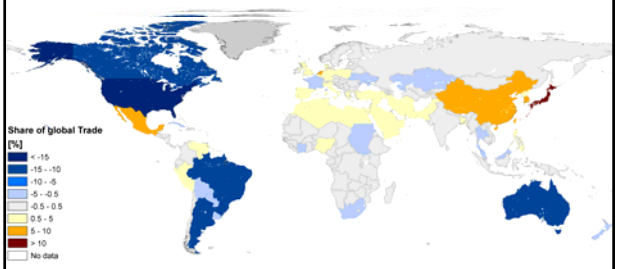
- HANPP efficiency (i.e. largely area-efficiency, i.e. energy yield per unit area and year) should be a highly important indicator for judging the ecological sustainability of bio-energy technologies.
- Agro-fuels are currently roughly 5-10 times less efficient than solid biofuels based on e.g. Miscanthus or short-rotation forests and roughly 25-50 times worse than integrated bioenergy/food schemes (i.e. use of agricultural residues)

⇒ Priority should be given to „cascade utilization" of biomass and to solid bio-fuels with a high energy yield per unit area (and usually also a good EROI)

Research questions (examples)

- Establish an embodied HANPP database (multiregional, for a large array of biomass-based products: food, fibre, energy)
- Integrated optimization of biomass production (cropping, grazing, livestock) and use (food, fibre and energy cascades)
- Trade issues, in particular with reference to trade between industrialized and developing countries with large importance of agrarian subsistence
- Trade-offs between carbon sequestration, bio-energy production and biodiversity

HANPP and global trade of biomass



Difference of „production“ and „consumption“ of „embodied HANPP“

Source: Erb et al. in prep.

Research questions (examples)

- Ecosystem services „transferred“ through biomass trade:
  - priced vs. unpriced services
  - trade-offs between productive and other services
  - policies, regulation
  - etc.
- Future scenarios dependent on
  - population growth
  - diets
  - agricultural policies & technologies
  - climate change
  - adaptation and mitigation
  - etc.

New: Download HANPP and land use data
http://www.uni-klu.ac.at/socec/inhalt/1088.htm